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3 October 1997

AGREEMENT

CONCERNING THE ADOPTION OF UNIFORM TECHNICAL PRESCRIPTIONS FOR WHEELED VEHICLES, EQUIPMENT AND PARTS WHICH CAN BE FITTED AND/OR BE USED ON WHEELED VEHICLES AND THE CONDITIONS FOR RECIPROCAL RECOGNITION OF APPROVALS GRANTED ON THE BASIS OF THESE PRESCRIPTIONS */

(Revision 2, including the amendments entered into force on 16 October 1995)

Addendum 100: Regulation No. 101

Amendment 1

Supplement 1 to the original version - Date of entry into force: 10 August 1997

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS EQUIPPED WITH AN INTERNAL COMBUSTION ENGINE WITH REGARD TO THE MEASUREMENT OF THE EMISSION OF CARBON DIOXIDE AND FUEL CONSUMPTION AND OF CATEGORIES M1 AND N1 VEHICLES EQUIPPED WITH AN ELECTRIC POWER TRAIN WITH REGARD TO THE MEASUREMENT OF ELECTRIC ENERGY CONSUMPTION AND RANGE

UNITED NATIONS

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*/ Former title of the Agreement:

Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, done at Geneva on 20 March 1958.

GE.97-24360

Title of the Regulation, amend to read: (See cover page)

Contents, list of annexes, amend to read:

"Annex 1: Essential characteristics of the internal combustion engine and information concerning the conduct of tests.

Annex 2: Essential characteristics of the electric power train and information concerning the conduct of tests.

Annex 3: Communication concerning the approval or extension or refusal or withdrawal of approval or production definitely discontinued of a vehicle type with regard to the measurement of emissions of carbon dioxide and fuel consumption or with regard to the measurement of electric energy consumption and range.

Annex 4: Arrangements of approval marks.

Annex 5: Method of measuring the emissions of carbon dioxide and fuel consumption.

Annex 6: Method of measuring the electric energy consumption.

Annex 7: Method of measuring the range of vehicles powered by an electric power train."

Text of the Regulation,

Paragraph 1, amend to read:

"1. SCOPE

This Regulation applies to the measurement of the emission of carbon dioxide (CO_2) and fuel consumption for M1 category vehicles, or to the measurement of electric energy consumption and range of categories M1 and N1 vehicles. 1/"

Paragraph 2.1., amend to read:

"2.1. "Approval of a vehicle" means the approval of a vehicle type with regard to the measurement of energy consumption (fuel or electric energy)."

Paragraph 2.2., amend to read:

"2.2. "Vehicle type" means a category of power driven vehicles which do not differ in such essential respects as body, drive train, transmission, traction battery (if applicable) tyres and unladen mass."

Paragraph 2.3., amend to read:

2.3. "Unladen mass" means the mass of the vehicle in running order without crew, passengers or load, but with the fuel tank full (if any), cooling liquid, service and traction batteries, oils, onboard charger, portable charger, tools and spare wheel, whatever is appropriate for the vehicle considered and if provided by the manufacturer of the vehicle;"

Insert a new paragraph 2.6., to read:

"2.6. "Test mass" for the pure electric vehicles, means the "reference mass" for the category M1 vehicles and the unladen mass plus half the full load for the category N1 vehicles."

Paragraphs 2.6. and 2.7. (former), renumber as paragraphs 2.7. and 2.8.

Insert new paragraphs 2.9 and 2.10., to read:

"2.9. "Drive train" means the combination of an electric motor and a power controller.

2.10. "Power train" means the combination of a drive train and a traction battery."

Paragraph 3.1., amend to read:

"3.1. The application for approval of a vehicle type with regard to the measurement of the emission of carbon dioxide and fuel consumption or to the measurement of electric energy consumption shall be submitted by the vehicle manufacturer or by his duly accredited representative."

Paragraph 3.2.1., amend to read:

"3.2.1. A description of the internal combustion engine type or the electric power train type comprising all the particulars referred to in annex 1 or annex 2. At the request of the technical service ....."

Paragraph 3.2.2., amend the reference to "annex 2" to read "annex 3".

Paragraph 3.3., amend to read:

"..... that this vehicle, if equipped with an internal combustion engine, conforms to the limit values applicable to that type, as described in Regulation No. 83."

Paragraph 4.1., amend to read:

"4.1. If the emissions of CO_2 and fuel consumption of internal combustion engine or the electric energy consumption of the vehicle type submitted for approval ....."

Paragraph 4.3., amend the reference to "annex 2" to read "annex 3".

Paragraph 4.8., amend the reference to "annex 3" to read "annex 4".

Paragraph 5.1., amend to read:

"5.1. General

The components liable to affect the emissions of CO_2 and fuel consumption or the electric energy consumption shall be so designed, constructed and ....."

Paragraph 5.2., amend to read:

"5.2. Description of tests for internal combustion engines"

Insert a new paragraph 5.3., to read:

"5.3. Description of tests for pure electric vehicles

5.3.1. The technical service in charge of the tests conducts the measurement of the electric energy consumption according to the method and test cycle described in annex 6 to this Regulation.

5.3.2. The technical service in charge of the tests conducts the measurement of the range of the vehicle according to the method described in annex 7.

The range measured by this method is the only one which may be included in sales promotional material.

5.3.3. The result of the electric energy consumption must be expressed in Watt hours per kilometre (Wh/km) and the range in km, both rounded to the nearest whole number."

Paragraph 5.3. (former), renumber as paragraph 5.4.

Paragraph 5.3.1. (former), renumber as paragraph 5.4.1., and amend to read:

"5.4.1. The CO_2 value or the value of electric energy consumption adopted as the type approval value shall be the value declared ....."

Paragraph 5.3.2. (former), renumber as paragraph 5.4.2., and amend to read:

"5.4.2. If the measured value of CO_2 or electric energy consumption exceeds the manufacturer's declared CO_2 or electric energy consumption value by more than ....."

Paragraph 6.1.1., amend to read:

"..... on the values of CO_2 and fuel consumption or electric energy consumption and that, in this case, ..."

Paragraph 7.1., amend to read:

"7.1. Vehicles powered by an internal combustion engine:

The type approval can be extended to vehicles ....."

Insert a new paragraph 7.2., to read:

"7.2. Vehicles powered by an electric power train.

Extensions may be granted after agreement with the technical service responsible for conducting the tests."

Paragraph 8, amend to read:

"8. **SPECIAL PROVISIONS**

In the future, vehicles with special energy efficient technologies may be offered ....."

Insert a new paragraph 9.3., to read:

"9.3. Vehicles powered by an internal combustion engine:"

Paragraph 9.3. (former), renumber as paragraph 9.3.1., and amend to read:

"9.3.1. As a general rule, measures to ensure the conformity of production with regard to CO_2 emissions from vehicles is checked on the basis of the description in the type approval certificate conforming to the model in annex 3 to this Regulation.

The control of production ....."

Paragraphs 9.3.1. and 9.3.1.1., renumber as paragraphs 9.3.1.1. and 9.3.1.1.1.

Paragraph 9.3.1.1.1. (former), renumber as paragraph 9.3.1.1.1.1., and amend the reference to "annex 4" to read "annex 5".

Paragraphs 9.3.1.1.2. and 9.3.1.1.3. (former), renumber as paragraphs 9.3.1.1.1.2. and 9.3.1.1.1.3.

Paragraph 9.3.1.2. (former), renumber as paragraph 9.3.1.1.2., and amend the reference to "annex 4" to read "annex 5".

Paragraphs 9.3.1.2.1. to 9.3.1.2.4. (former), renumber as paragraphs 9.3.1.1.2.1. to 9.3.1.1.2.4.

Paragraphs 9.4. to 9.4.5.3. (former), renumber as paragraphs 9.3.2. to 9.3.2.5.3.

Paragraphs 9.5. to 9.5.6. (former), renumber as paragraphs 9.3.3. to 9.3.3.6.

Insert new paragraphs 9.4. to 9.4.2.5., to read:

"9.4. Vehicles powered by an electric power train:

As a general rule, measures to ensure the conformity of production with regard to electric energy consumption is checked on the basis of the description in the type approval certificate set out in annex 3 to this Regulation.

9.4.1. The holder of the approval shall, in particular:

9.4.1.1. Ensure the existence of procedures for the effective control of product quality;

9.4.1.2. Have access to the equipment necessary for checking conformity with each approved type;

9.4.1.3. Ensure that the data concerning the test results are recorded and that the annexed documents are available during a period to be agreed with the administrative service;

9.4.1.4. Analyze the results of each type of test so as to monitor and ensure the consistency of the characteristics of the product, taking into account the variations admissible in industrial manufacture;

9.4.1.5. Make sure that for each type of vehicle tests prescribed in annex 6 to this Regulation are carried out;

9.4.1.6. Make sure that any collections of samples or test pieces demonstrating non-conformity with the type of test under consideration is followed by a subsequent sampling and a further test. All necessary steps shall be taken to re-establish the conformity of production.

9.4.2. The competent authorities issuing the approval may verify at any time the methods applied in each production unit.

9.4.2.1. In every inspection, the records of tests and production monitoring shall be communicated to the visiting inspector.

9.4.2.2. The inspector may select at random the samples to be tested in the manufacturer's laboratory. The minimum number of samples may be determined on the basis of the results of the manufacturer's own checks.

9.4.2.3. When the quality standard does not seem satisfactory or when it seems necessary to verify the validity of the tests conducted under paragraph 9.4.2.2., the inspector shall collect samples to be sent to the technical service which carried out the approval tests.

9.4.2.4. The competent authorities may carry out all the tests prescribed in this Regulation.

9.4.2.5. If, during inspections, negative results are observed, the competent authority shall ensure that all necessary steps are taken to re-establish conformity of production as soon as possible."

Paragraphs 10.2. and 11, amend the reference to "annex 2" to read "annex 3" (twice).

Annex 1, the title, amend to read:

"Annex 1

ESSENTIAL CHARACTERISTICS OF THE INTERNAL COMBUSTION ENGINE AND INFORMATION CONCERNING THE CONDUCT OF TESTS"

Insert a new annex 2, to read:

"Annex 2

ESSENTIAL CHARACTERISTICS OF THE ELECTRIC POWER TRAIN AND INFORMATION CONCERNING THE CONDUCT OF TESTS

1. Description of the traction battery

1.1. Trade name and mark of the battery: . . . . . .
1.2. Kind of electro-chemical couple: . . . . . .
1.3. Nominal voltage: V
1.4. Battery maximum thirty minutes power (constant power discharge): . . . . . kW
1.5. Battery performance in 2 h discharge (constant power or constant current): 3/
1.5.1. Battery energy: . . . . . kWh
1.5.2. Battery capacity: . . . . . Ah in 2 h
1.5.3. End of discharge voltage value: V

1.6. Indication of the end of the discharge that leads to a compulsory stop of the vehicle: 4/ . . . . . .
1.7. Battery mass: . . . . . kg

2. Description of the drive train

2.1. General

2.1.1. Make: . . . . . .
2.1.2. Type: . . . . . .
2.1.3. Use 3/ : Monomotor/multimotors (number): . . . . . .
2.1.4. Transmission arrangement: parallel/transaxial/others, to precise:
. . . . . .
2.1.5. Test voltage: V
2.1.6. Motor nominal speed: . . . . . min^{-1}
2.1.7. Motor maximum speed: . . . . . min^{-1}
or by default:
reducer outlet shaft/gear box speed (specify gear engaged):
. . . . . min^{-1}
2.1.8. Maximum power speed: 2/ . . . . . min^{-1}
2.1.9. Maximum power: . . . . . kW
2.1.10. Maximum thirty minutes power: . . . . . kW
2.1.11. Flexible range (where P $\geq$ 90 % of max. power):
speed at the beginning of range: . . . . . min^{-1}
speed at the end of range: . . . . . min^{-1}

2.2. Motor

2.2.1. Working principle:
2.2.1.1. direct current/alternating current 3/ /number of phases: . . . . .
2.2.1.2. separate excitation/series/compound 3/
2.2.1.3. synchron/asynchron 3/
2.2.1.4. coiled rotor/with permanent magnets/with housing 3/
2.2.1.5. number of poles of the motor: . . . . . .
2.2.2. Inertia mass: . . . . . .

2.3. Power controller

2.3.1. Make
2.3.2. Type
2.3.3. Control principle: vectorial/open loop/closed/other (to be
specified): 3/ . . . . . .
2.3.4. Maximum effective current supplied to the motor: 2/ . . . . . A
during. . . . . seconds
2.3.5. Voltage range use: . . . . . V to V

2.4. Cooling system:

motor : liquid/air 3/
controller : liquid/air 3/

2.4.1. Liquid-cooling equipment characteristics:
2.4.1.1. Nature of the liquid . . . . . circulating pumps : yes/no 3/
2.4.1.2. Characteristics or make(s) and type(s) of the pump: . . . . . .
2.4.1.3. Thermostat: setting: . . . . . .
2.4.1.4. Radiator: drawing(s) or make(s) and type(s): . . . . . .

2.4.1.5. Relief valve: pressure setting: . . . . . .
2.4.1.6. Fan: characteristics or make(s) and type(s): . . . . . .
2.4.1.7. Fan duct: . . . . . .

2.4.2. Air-cooling equipment characteristics
2.4.2.1. Blower: characteristics or make(s) and type(s): . . . . . .
2.4.2.2. Standard air ducting: . . . . . .
2.4.2.3. Temperature regulating system: yes/no 3/
2.4.2.4. Brief description: . . . . . .
2.4.2.5. Air filter: . . . . . make(s): . . . . . type(s) . . . . . .

2.4.3. Temperatures admitted by the manufacturer

		maximum temperature
2.4.3.1.	Motor outlet:	.....°C
2.4.3.2.	controller inlet:	.....°C
2.4.3.3.	at motor reference point(s):	.....°C
2.4.3.4.	at controller reference point(s):	.....°C

2.5. Insulating category: . . . . . .

2.6. International protection (IP)-code: . . . . . .

2.7. Lubrication system principle: 3/ Bearings: friction/ball
Lubricant: grease/oil
Seal: yes/no
Circulation: with/without

3. Description of the transmission

3.1. Drive wheels: front/rear/4 x 4 3/
3.2. Type of transmission: manual/automatic 3/
3.3. Number of gear ratios: . . . . . .

3.3.1.

Gear	Wheel speed	Gear ratio	Motor speed
1			
2			
3			
4			
5			
Reverse			

min. CVT (Continuous Variable Transmission): . . . . . .
max. CVT: . . . . . .

3.4. Recommendations for changing the gears

1 → 2:	2 → 1: . . . . .
2 → 3:	3 → 2: . . . . .
3 → 4:	4 → 3: . . . . .
4 → 5:	5 → 4: . . . . .
overdrive in:	overdrive out: . . . . .

3.5. Tyres:
Dimensions: . . . . . .
Rolling circumference under load: . . . . . .
Recommended pressure: . . . . . .

3.6. Inertia mass:
3.6.1. Equivalent inertia mass of complete front axle: . . . . . .
3.6.2. Equivalent inertia mass of complete rear axle: . . . . . .

4. Charge

4.1. Charger: on board/external 3/
In case of an external unit, define the charger (trademark, model):
. . . . . .
4.2. Description of the normal profile of charge: . . . . . .
4.3. Specification of mains:
4.3.1. Type of mains: single phase/three phase 3/
4.3.2. Voltage: . . . . . .
4.4. Rest period recommended between the end of the discharge and the start of the charge: . . . . . .
4.5. Theoretical duration of a complete charge:

1/ For non-conventional motors or systems, the manufacturer will supply data equivalent to those requested hereafter.
2/ Specify tolerances.
3/ Strike out what does not apply.
4/ If applicable."

Annex 2 (former), renumber as annex 3, and amend as follows:

Item 6.5., amend to read:

"6.5. Internal combustion engine 2/"

Insert a new item 6.6., to read:

"6.6. Electric power train 1/

6.6.1. Drive train:

6.6.1.1. Maximum net power : . . . . . kW, at . . . . . to . . . . . min^{-1}
6.6.1.2. Maximum thirty minutes power: . . . . . kW
6.6.1.3. Working principle: . . . . . .
6.6.2. Traction battery:
6.6.2.1. Nominal voltage: V
6.6.2.2. Capacity (2 h rate): . . . . . Ah
6.6.2.3. Battery maximum thirty minutes power: . . . . . kW
6.6.2.4. Charger: on board/external 2/"

Items 6.6. to 6.6.5. (former), renumber as items 6.7. to 6.7.5.

Insert a new item 7.1., to read:

"7.1. Internal combustion engine 2/"

Items 7.1. to 7.2.3. (former), renumber as items 7.1.1. to 7.1.2.3.

Insert new items 7.2. to 7.2.2.2., to read:

"7.2. Pure electric vehicles 2/
7.2.1. Measurement of electric energy consumption.
7.2.1.1. Electric energy consumption: . . . . . Wh/km
7.2.1.2. Total time out of tolerance for the conduct of the cycle: . . sec

7.2.2. Measurement of range:
7.2.2.1. Range: . . . . . km
7.2.2.2. Total time out of tolerance for the conduct of the cycle: . . sec"

Annex 3 (former), renumber as annex 4, and in the caption below Model A approval mark, amend the words "emissions of CO_2 and fuel consumption" to read: "emissions of CO_2 and fuel consumption or to the measurement of electric energy consumption and range."

Annex 4 (former), renumber as annex 5 and amend the title to read:

"Annex 5

METHOD OF MEASURING EMISSIONS OF CARBON DIOXIDE AND FUEL CONSUMPTION OF INTERNAL COMBUSTION ENGINES"

Insert a new annex 6, to read:

"Annex 6

METHOD OF MEASURING THE ELECTRIC ENERGY CONSUMPTION

1. **TEST SEQUENCE**

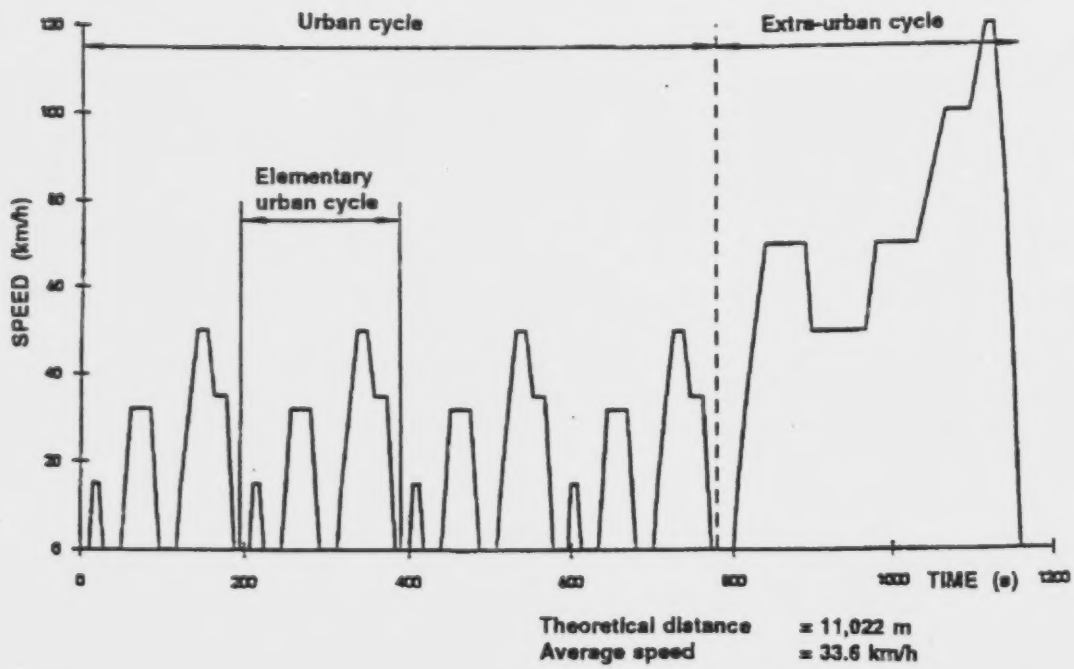
1.1. Composition

The test sequence is composed of two parts (see figure 1):

(a) an urban cycle made of four elementary urban cycles;
(b) an extra-urban cycle.

In case of a manual gear box with several gears, the operator changes the gear according to the manufacturer's specifications.
If the vehicle has several driving modes, which may be selected by the driver, the operator shall select the one to best match the target curve.

Figure 1
Test sequence - M1 and N1 categories of vehicles



1.2. Urban cycle

The urban cycle is composed of four elementary cycles of 195 seconds each and lasts 780 seconds in total.

Description of the elementary urban cycle is given in figure 2 and table 1.

Figure 2

Elementary urban cycle (195 seconds)

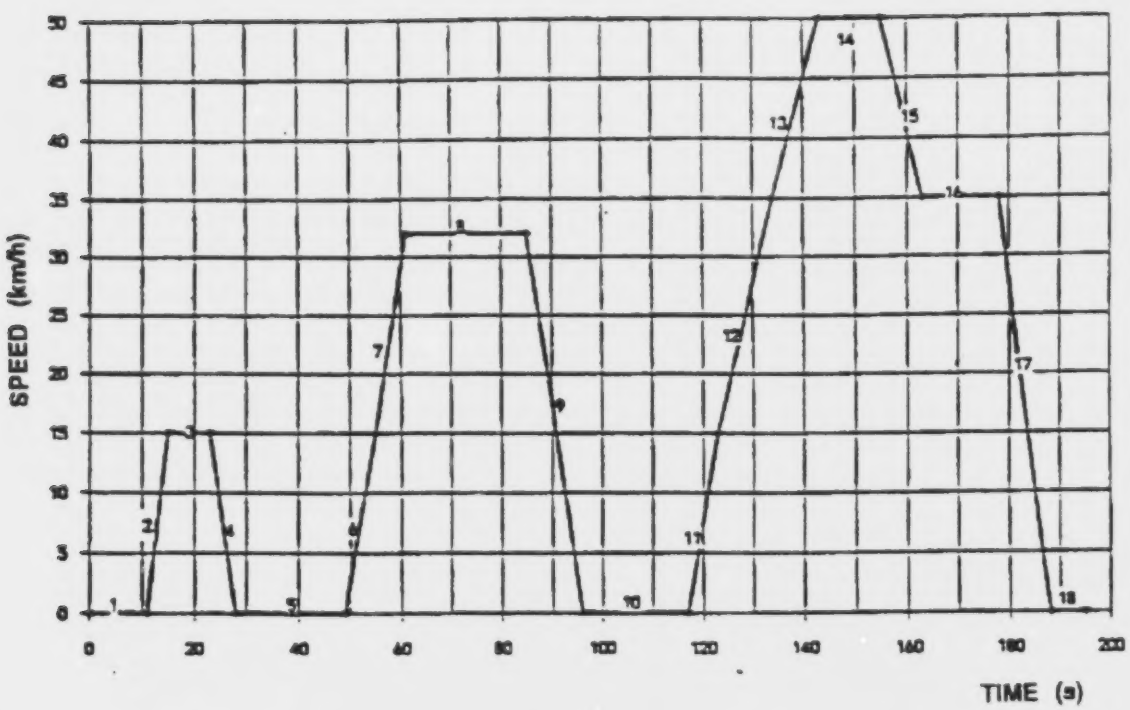


Table 1
Elementary urban cycle

Operation N°	Operation type	ELEMENTARY URBAN CYCLE			Operation duration (s)	Mode duration (s)	Total time (s)
		Mode N°	Acceleration (m/s^2)	Speed (km/h)			
1	Stop	1	0.00	0	11	11	11
2	Acceleration	2	1.04	0-15	4	4	15
3	Constant speed	3	0.00	15	8	8	23
4	Deceleration	4	-0.83	15-0	5	5	28
5	Stop	5	0.00	0	21	21	49
6	Acceleration	6	0.69	0-15	6	12	55
7	Acceleration		0.79	15-32	6		61
8	Constant speed	7	0.00	32	24	24	85
9	Deceleration	8	-0.81	32-0	11	11	96
10	Stop	9	0.00	0	21	21	117
11	Acceleration	10	0.69	0-15	6	26	123
12	Acceleration		0.51	15-35	11		134
13	Acceleration		0.46	35-50	9		143
14	Constant speed	11	0.00	50	12	12	155
15	Deceleration	12	-0.52	50-35	8	8	163
16	Constant speed	13	0.00	35	15	15	178
17	Deceleration	14	-0.97	35-0	10	10	188
18	Stop	15	0.00	0	7	7	195

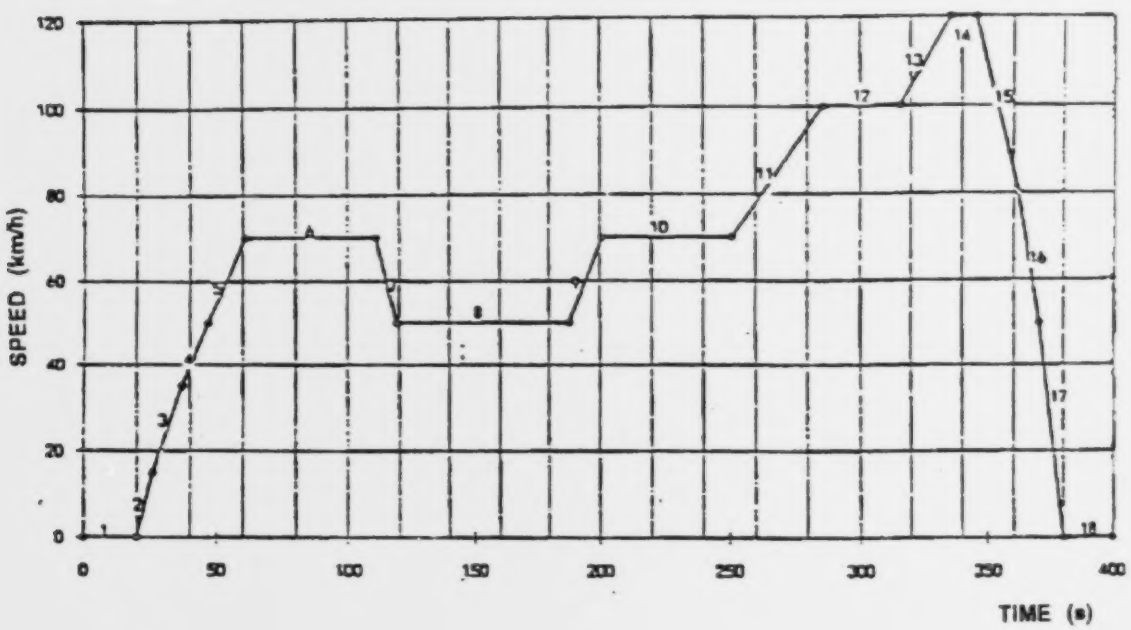
Generalities	in time (s)	in percentage
Stop	60	30.77
Acceleration	42	21.54
Constant speed	59	30.26
Deceleration	34	17.44
Total	195	100.00

Average speed (km/h)	18.77
Working time (s)	195
Theoretical distance by elementary urban cycle (m)	1017
Theoretical distance for four elementary urban cycles (m)	4067

1.3. Extra-urban cycle

The description of the extra-urban cycle is given in figure 3 and table 2.

Figure 3
Extra-urban cycle (400 seconds)



Note: The procedure to be adopted when the vehicle failed to meet the speed requirements of this curve is detailed in item 1.4.

Table 2

Operation N°	Operation type	EXTRA-URBAN CYCLE			Operation duration (s)	Mode duration (s)	Total time (s)
		Mode N°	Acceleration (m/s^2)	Speed (km/h			
1	Stop	1	0.00	0	20	20	20
2	Acceleration	2	0.69	0-15	6	41	26
3	Acceleration		0.51	15-35	11		37
4	Acceleration		0.42	35-50	10		47
5	Acceleration		0.40	50-70	14		61
6	Constant speed	3	0.00	70	50	50	111
7	Deceleration	4	-0.69	70-50	8	8	119
8	Constant speed	5	0.00	50	69	69	188
9	Acceleration	6	0.43	50-70	13	13	201
10	Constant speed	7	0.00	70	50	50	251
11	Acceleration	8	0.24	70-100	35	35	286
12	Constant speed	9	0.00	100	30	30	316
13	Acceleration	10	0.28	100-120	20	20	336
14	Constant speed	11	0.00	120	10	10	346
15	Deceleration	12	-0.69	120-80	16	34	362
16	Deceleration		-1.04	80-50	8		370
17	Deceleration		-1.39	50-0	10		380
18	Stop	13	0.00	0	20	20	400

Generalities	in time (s)	in percentage
Stop	40	10.00
Acceleration	109	27.25
Constant speed	209	52.25
Deceleration	42	10.50
Total	400	100.00

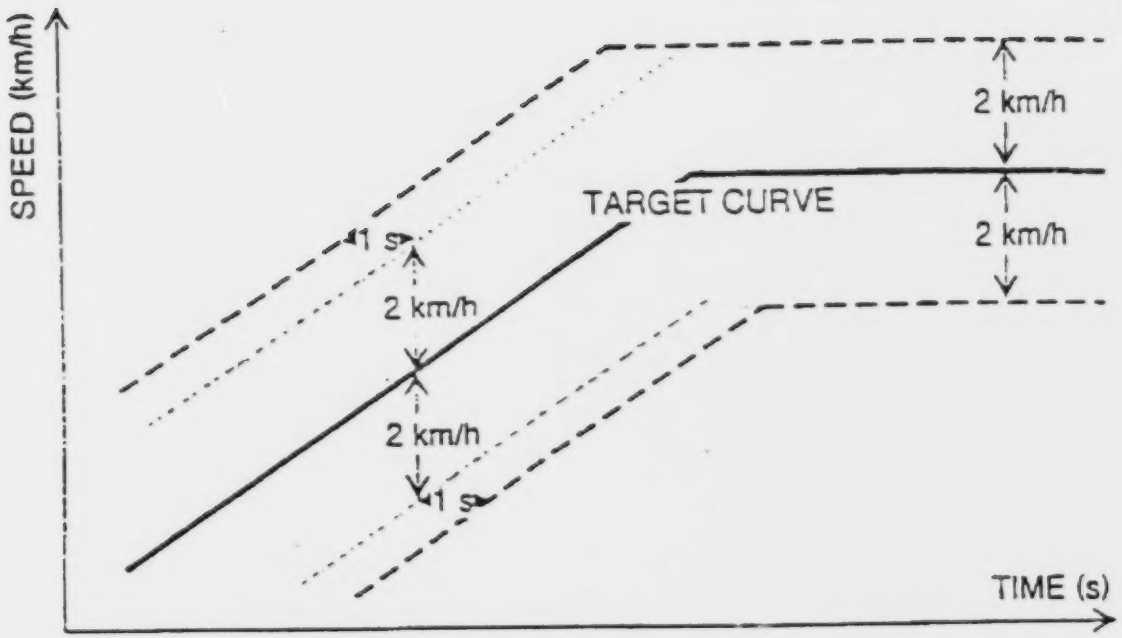
Average speed (km/h)	62.60
Working time (s)	400
Theoretical distance (m)	6956

1.4. Tolerance

Tolerances are given in figure 4.

Figure 4

Speed tolerance



Tolerances on speed (± 2 km/h) and on time (± 1 s) are geometrically combined at each point as represented in figure 4.

Below 50 km/h, deviations beyond this tolerance are permitted as follows:

(a) at gear changes for a duration less than 5 seconds,
(b) and up to five times per hour at other times, for a duration less than 5 seconds each.

The total time out of tolerance has to be mentioned in the test report.

Over 50 km/h, it is accepted to go beyond tolerances provided the accelerator pedal is fully depressed.

2. **TEST METHOD**

2.1. Principle

The test method described hereafter permits to measure the electric energy consumption expressed in Wh/km:

2.2. Parameters, units and accuracy of measurements

Parameter	Units	Accuracy	Resolution
Time	s	± 0.1 s	0.1 s
Distance	m	± 0.1 %	1 m
Temperature	°C	± 1 °C	1°C
Speed	km/h	± 1 %	0.2 km/h
Mass	kg	± 0.5 %	1 kg
Energy	Wh	± 0.2 %	Class 0.2 s according to IEC 687

IEC = International Electrotechnical Commission

2.3. Vehicle

2.3.1. Condition of the vehicle

2.3.1.1. The vehicle tyres shall be inflated to the pressure specified by the vehicle manufacturer when the tyres are at the ambient temperature.

2.3.1.2. The viscosity of the oils for the mechanical moving parts shall conform to the specification of the vehicle manufacturer.

2.3.1.3. The lighting and light-signalling and auxiliary devices shall be off, except those required for testing and usual day-time operation of the vehicle.

2.3.1.4. All energy storage systems available for other than traction purposes (electric, hydraulic, pneumatic, etc.) shall be charged up to their maximum level specified by the manufacturer.

2.3.1.5. If the batteries are operated above the ambient temperature, the operator shall follow the procedure recommended by the car manufacturer in order to keep the temperature of the battery in the normal operating range.
The manufacturer's agent shall be in a position to attest that the thermal management system of the battery is neither disabled nor reduced.

2.3.1.6. The vehicle must have undergone at least 300 km during the seven days before the test with those batteries that are installed in the test vehicle.

2.4. Operation mode

All the tests are conducted at a temperature of between 20°C and 30°C.

The test method includes the four following steps:

(a) Initial charge of the battery;
(b) Application twice of the cycle made of four elementary urban cycles and an extra-urban cycle;
(c) Charging the battery;
(d) Calculation of the electric energy consumption.

Between the steps, if the vehicle shall move, it is pushed to the following test area (without regenerative recharging).

2.4.1. Initial charge of the battery

Charging the battery consists of the following procedures:

2.4.1.1. Discharge of the battery

The procedure starts with the discharge of the battery of the vehicle while driving (on the test track, on a chassis dynamometer, etc.) at a steady speed of 70 % ± 5 % from the maximum thirty minutes speed of the vehicle.

Stopping the discharge occurs:

(a) when the vehicle is not able to run at 65 % of the maximum thirty minutes speed;
(b) or when an indication to stop the vehicle is given to the driver by the standard on-board instrumentation, or
(c) after covering the distance of 100 km.

2.4.1.2. Application of a normal overnight charge

The battery shall be charged according to the following procedure.

2.4.1.2.1. Normal overnight charge procedure

The charge is carried out:

(a) with the on-board charger if fitted,
(b) with an external charger recommended by the manufacturer, the connection being made with the domestic plug whose pattern has been recommended by the manufacturer,
(c) in an ambient temperature comprised between 20°C and 30°C.

The procedure excludes all types of special charges that could be automatically or manually initiated like, for instance, the equalization charges or the servicing charges.

The car manufacturer shall be in a position to attest that during the test, a special charge procedure has not occurred.

2.4.1.2.2. End of charge criteria

The end of charge criteria corresponds to a charging time of 12 hours except if a clear indication is given to the driver by the standard instrumentation that the battery is not yet fully charged.

In this case,

$$\text{the maximum time is} = \frac{3 \cdot \text{claimed battery capacity (Wh)}}{\text{mains power supply (W)}}$$

2.4.1.2.3. Fully charged battery

Battery having been charged according to overnight charge procedure until the end of charge criteria.

2.4.2. Application of the cycle and measurement of the distance

The end of charging time t_0 (plug off) is reported.

The chassis dynamometer shall be set with the method described in appendix 1 to this annex.

Starting within 4 hours from t_0, the cycle made of four elementary urban cycles and an extra-urban cycle is run twice on a chassis dynamometer (test distance: 22 km, test duration: 40 minutes).

At the end, the measure D of the covered distance in km is recorded.

2.4.3. Charge of the battery

The vehicle shall be connected to the mains within the 30 minutes after the conclusion of the cycle made of four elementary urban cycles and an extra-urban cycle, carried out twice.

The vehicle is being charged according to normal overnight charge procedure (see paragraph 2.4.1.2. above).

The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy E delivered from the mains, as well as its duration.

Charging is stopped after 24 hours from the previous end of charging time (t_0).

Note:
In case of a mains power cut, the 24 hours period will be extended accordingly to the cut duration.
Validity of the charge will be discussed between the technical services of the approval laboratory and the vehicle's manufacturer.

2.4.4. Electric energy consumption calculation

Energy E in Wh and charging time measurements are recorded in the test report.

The electric energy consumption C is defined by the formula:

$$C = \frac{E}{D}$$ (expressed in Wh/km and rounded to the nearest whole number)

where D = range (km)."

Insert a new annex 6 - appendix 1, to read:

"Annex 6 - Appendix 1

DETERMINATION OF THE TOTAL ROAD LOAD POWER OF A VEHICLE AND CALIBRATION OF THE DYNAMOMETER

1. **INTRODUCTION**

The purpose of this appendix is to define the method of measuring the total road load power of a vehicle with a statistical accuracy of ± 4 % at a constant speed and to reproduce this measured road load power on a dynamometer with an accuracy of ± 5 %.

2. **CHARACTERISTICS OF THE TRACK**

The test road layout shall be level, straight and free of obstacles or wind barriers which adversely affect the variability of road load measurement.

The test road longitudinal slope shall not exceed ± 2 %. This slope is defined as the ratio of the difference in elevation between both ends of the test road and its overall length. In addition, the local inclination between any two points 3 m apart shall not deviate by more than ± 0.5 % from this longitudinal slope.

The maximum cross-sectional camber of the test road shall be 1.5 % or less.

3. **ATMOSPHERIC CONDITIONS**

3.1. Wind

Testing shall be performed at wind speeds averaging less than 3 m/s with peak speeds less than 5 m/s. In addition, the vector component of the wind speed across the test track must be less than 2 m/s. Wind velocity shall be measured at 0.7 m above the track surface.

3.2. Humidity

The track shall be dry.

3.3. Reference conditions

Barometric pressure	H_0 = 100 kPa
Temperature	T_0 = 293 K (20°C)
Air density	d_0 = 1.189 kg/m^3

3.3.1. Air density

3.3.1.1. The air density during the test, calculated as described in paragraph 3.3.1.2. below, shall not differ by more than 7.5 % from the air density under the reference conditions.

3.3.1.2. The air density shall be calculated by the formula:

$$d_T = d_0 \times \frac{H_T}{H_0} \times \frac{T_0}{T_T}$$

where:

d_T is the air density during the test (kg/m^3)
d_0 is the air density at reference conditions (kg/m^3)
H_T is the total barometric pressure during the test (kPa)
T_T is absolute temperature during the test (K).

3.3.2. Ambient conditions

3.3.2.1. The ambient temperature shall be between 5°C (278 K) and 35°C (308 K) and the barometric pressure between 91 kPa and 104 kPa. The relative humidity shall be less than 95 %.

3.3.2.2. However, with the manufacturer's agreement, the tests may be made at lower ambient temperatures down to 1°C. In this case the correction factor calculated for 5°C should be used.

4. **PREPARATION OF THE VEHICLE**

4.1. Running-in

The vehicle shall be in normal running order and adjustment after having been run in for at least 300 km. The tyres shall be run in at the same time as the vehicle or shall have a tread depth within 90 and 50 % of the initial tread depth.

4.2. Checks

The following checks shall be made in accordance with the manufacturer's specifications for the use considered: wheels, wheel rims, tyres (make, type, pressure), front axle geometry, brake adjustment (elimination of parasitic drag), lubrication of front and rear axles, adjustment of the suspension and vehicle ground clearance, etc. Check that during freewheeling, there is no electrical braking.

4.3. Preparation for the test

4.3.1. The vehicle shall be loaded to its test mass including driver and measurement equipments, spread in a uniform way in the loading areas.

4.3.2. The windows of the vehicle shall be closed. Any covers for air conditioning systems, headlamps, etc. shall be closed.

4.3.3. The vehicle shall be clean.

4.3.4. Immediately before the test, the vehicle shall be brought to the normal running temperature in an appropriate manner.

5. **SPECIFIED SPEED V**

The specified speed is required for determining the running resistance at the reference speed from the running resistance curve. To determine the running resistance as a function of vehicle speed in the vicinity of the reference speed V_0, running resistances shall be measured at the specified speed V. At least four to five points indicating the specified speeds along with the reference speeds, are desired to be measured.

Table 1 shows the specified speeds in accordance with the category of the vehicle. The asterisk * indicates the reference speed in the table.

Table 1

Category V max.	Specified speeds (km/h)					
> 130	120**	100	80*	60	40	20
130 - 100	90	80*	60	40	20	-
100 - 70	60	50*	40	30	20	-
< 70	50**	40*	30	20	-	-
** if it could be reached by the vehicle.						

6. **ENERGY VARIATION DURING COAST-DOWN**

6.1. Total road load power determination

6.1.1. Measurement equipment and accuracy

The margin of measurement error shall be less than 0.1 second for time and less than ± 0.5 km/h for speed.

6.1.2. Test procedure

6.1.2.1. Accelerate the vehicle to a speed of 5 km/h greater than the speed at which test measurement begins.

6.1.2.2. Put the gearbox to neutral, or disconnect the power supply.

6.1.2.3. Measure the time t_1 taken by the vehicle to decelerate from:

V2 = V + Δ Vkm/h to V1 = V - Δ Vkm/h

where:

Δ V ≤ 5 km/h for nominal speed ≤ 50 km/h

Δ V ≤ 10 km/h for nominal speed > 50 km/h

6.1.2.4. Carry out the same test in the opposite direction, measuring time t_2.

6.1.2.5. Take the average T1 of the two times t_1 and t_2.

6.1.2.6. Repeat these tests until the statistical accuracy (p) of the average.

$$T = \frac{1}{n}\sum_{i=1}^{n} Ti$$

is equal to or less than 4 % (p ≤ 4 %).

The statistical accuracy (p) is defined by:

$$p = \frac{T.s}{\sqrt{n}} \times \frac{100}{\bar{T}}$$

where:

T is the coefficient given by the table below;
s is the standard deviation

$$s = \sqrt{\sum_{i=1}^{n} \frac{(Ti - \bar{T})^2}{n - 1}}$$

n is the number of tests

n	4	5	6	7	8	9	10
t	3.2	2.8	2.6	2.5	2.4	2.3	2.3
$t/\sqrt{n}$	1.6	1.25	1.06	0.94	0.85	0.77	0.73

6.1.2.7 Calculation of the running resistance force

The running resistance force F at the specified speed V is calculated as follows :

$$F = (M + M_r) \frac{2\Delta V}{\Delta T} \frac{1}{3.6} \quad N$$

Where:

M is the test mass.
M_r is the equivalent inertia mass of all the wheels and vehicle portions rotating with the wheels during coast down on the road. M_r should be measured or calculated by an appropriate manner.

6.1.2.8. The running resistance determined on the track shall be corrected to the reference ambient conditions as follows :

F corrected = k x F measured

$$k = \frac{R_R}{R_T}\left[1+K_R(t-t_0)\right] + \frac{R_{AERO}}{R_T}\,\frac{d_0}{d_t}$$

where :

R_R is the rolling resistance at speed V
R_{AERO} is the aerodynamic drag at speed V
R_T is the total road load = R_R+R_{AERO}
K_R is the temperature correction factor of rolling resistance, taken to be equal to: 3.6×10^{-3}/°C
t is the road test ambient temperature in °C
t_0 is the reference ambient temperature = 20°C
d_t is the air density at the test conditions
d_0 is the air density at the reference conditions (20°C, 100 KPa) = 1.189 kg/m3.

The ratios R_R/R_T and R_{AERO}/R_T shall be specified by the vehicle manufacturer on the basis of the data normally available to the company.

If these values are not available, subject to the agreement of the manufacturer and the technical service concerned, the figures for the rolling/total resistance ratio given by the following formula may be used:

$$\frac{R_R}{R_T} = aM_{HP} + b$$

Where:

M_{HP} is the test mass

and for each speed the coefficients a and b are as shown in the following table:

V (km/h)	a	b
20	$7.24 \cdot 10^{-5}$	0.82
30	$1.25 \cdot 10^{-4}$	0.67
40	$1.59 \cdot 10^{-4}$	0.54
50	$1.86 \cdot 10^{-4}$	0.42
90	$1.71 \cdot 10^{-4}$	0.21
120	$1.57 \cdot 10^{-4}$	0.14

6.2. Setting of the dynamometer

The purpose of this procedure is to simulate on the dynamometer the total road load power at a given speed.

6.2.1. Measurement equipment and accuracy

The measuring equipment shall be similar to that used on the track.

6.2.2. Test procedure

6.2.2.1. Install the vehicle on the dynamometer.

6.2.2.2. Adjust the tyre pressure (cold) of the driving wheels as required for the chassis dynamometer.

6.2.2.3. Adjust the equivalent inertia mass of the chassis dynamometer, according to table 2.

Table 2

Test mass M_{HP} (kg)	Equivalent inertia I (kg)
$M_{HP} \leq 480$	455
$480 < M_{HP} \leq 540$	510
$540 < M_{HP} \leq 595$	570
$595 < M_{HP} \leq 650$	625
$650 < M_{HP} \leq 710$	680
$710 < M_{HP} \leq 765$	740
$765 < M_{HP} \leq 850$	800
$850 < M_{HP} \leq 965$	910
$965 < M_{HP} \leq 1,080$	1,020
$1,080 < M_{HP} \leq 1,190$	1,130
$1,190 < M_{HP} \leq 1,305$	1,250
$1,305 < M_{HP} \leq 1,420$	1,360
$1,420 < M_{HP} \leq 1,530$	1,470
$1,530 < M_{HP} \leq 1,640$	1,590
$1,640 < M_{HP} \leq 1,760$	1,700
$1,760 < M_{HP} \leq 1,870$	1,810
$1,870 < M_{HP} \leq 1,980$	1,930
$1,980 < M_{HP} \leq 2,100$	2,040
$2,100 < M_{HP} \leq 2,210$	2,150
$2,210 < M_{HP} \leq 2,380$	2,270
$2,380 < M_{HP} \leq 2,610$	2,270
$2,610 < M_{HP}$	2,270

6.2.2.4. Bring the vehicle and the chassis dynamometer to the stabilized operating temperature, in order to approximate the road conditions.

6.2.2.5. Carry out the operations specified in paragraph 6.1.2. with the exception of paragraphs 6.1.2.4. and 6.1.2.5., replacing M_{HP} by I and M_T by M_{rm} in the formula given in paragraph 6.1.2.7.

6.2.2.6. Adjust the brake to reproduce the corrected running resistance half payload (paragraph 6.1.2.8.) and to take into account the difference between the vehicle mass on the track and the equivalent inertia test mass (I) to be used. This may be done by calculating the mean corrected road coast down time from V_2 to V_1 and reproducing the same time on the dynamometer by the following relationship:

$$T_{corrected} = (I + M_{rm}) \frac{2\Delta V}{F_{corrected}} \cdot \frac{1}{3.6}$$

where:

I is the flywheel equivalent inertia mass of chassis dynamometer.

M_{rm} is the equivalent inertia mass of the powered wheels and vehicle portions rotating with the wheels during coast down. M_{rm} shall be measured or calculated by an appropriate manner.

6.2.2.7. The power P_a to be absorbed by the bench should be determined in order to enable the same total road load power to be reproduced for the same vehicle on different days or on different chassis dynamometers of the same type."

Insert a new annex 7, to read:

"Annex 7

METHOD OF MEASURING THE RANGE OF VEHICLES
POWERED BY AN ELECTRIC POWER TRAIN

1. **MEASUREMENT OF THE RANGE**

The test method described hereafter permits to measure the range of vehicles powered by an electric power train, expressed in km.

2. **PARAMETERS, UNITS AND ACCURACY OF MEASUREMENTS**

Parameters, units and accuracy of measurements shall be as follows:

Parameters, units and accuracy of measurements

Parameter	Unit	Accuracy	Resolution
Time	s	± 0.1 s	0.1 s
Distance	m	± 0.1 %	1 m
Temperature	°C	± 1°C	1°C
Speed	km/h	± 1 %	0.2 km/h
Mass	kg	± 0.5 %	1 kg

5. TEST CONDITIONS

5.1. Condition of the vehicle

5.1.1. The vehicle tyres shall be inflated to the pressure specified by the vehicle manufacturer when the tyres are at the ambient temperature.

5.1.2. The viscosity of the oils for the mechanical moving parts shall conform to the specifications of the vehicle manufacturer.

5.1.3. The lighting and light-signalling and auxiliary devices shall be off, except those required for testing and usual daytime operation of the vehicle.

5.1.4. All energy storage systems available for other than traction purposes (electric, hydraulic, pneumatic, etc.) shall be charged up to their maximum level specified by the manufacturer.

5.1.5. If the batteries are operated above the ambient temperature, the operator shall follow the procedure recommended by the vehicle manufacturer in order to keep the temperature of the battery in the normal operating range.

The manufacturer's agent shall be in a position to attest that the thermal management system of the battery is neither disabled nor reduced.

5.1.6. The vehicle must have undergone at least 300 km during the seven days before the test with those batteries that are installed in the test vehicle.

3.2. Climatic conditions

For testing performed outdoors, the ambient temperature shall be between 5°C and 32°C.

The indoors testing shall be performed at a temperature between 20°C and 30°C.

4. **OPERATION MODES**

The test method includes the following steps:

(a) Initial charge of the battery.
(b) Application of the cycle and measurement of the range.

Between the steps, if the vehicle shall move, it is pushed to the following test area (without regenerative recharging).

4.1. Initial charge of the battery

Charging the battery consists of the following procedures:

Note: "Initial charge of the battery" applies to the first charge of the battery, at the reception of the vehicle. In case of several combined tests or measurements, carried out consecutively, the first charge carried out shall be an "initial charge of the battery" and the following may be done in accordance with the "normal overnight charge" procedure.

4.1.1. Discharge of the battery

The procedure starts with the discharge of the battery of the vehicle while driving (on the test track, on a chassis dynamometer etc.) at a steady speed of 70% ± 5% from the maximum thirty minutes speed of the vehicle.

Stopping the discharge occurs:

(a) when the vehicle is not able to run at 65% of the maximum thirty minutes speed;
(b) or when an indication to stop the vehicle is given to the driver by the standard on-board instrumentation, or
(c) after covering the distance of 100 km.

4.1.2. Application of a normal overnight charge

The battery shall be charged according to normal overnight charge procedure for a period not exceeding 12 hours (see paragraph 2.4.1.2.1. of annex 6).

4.2. Application of the cycle and measurement of the range

The test sequence as defined in paragraph 1.1. of annex 6 is applied on a chassis dynamometer adjusted as described in appendix 1 of annex 6, until the end of the test criteria is reached.

The end of the test criteria is when the vehicle is not able to meet the target curve up to 50 km/h, or when an indication from the standard on-board instrumentation is given to the driver to stop the vehicle.

Then the vehicle shall be slowed down to 5 km/h by releasing the accelerator pedal, without touching the brake pedal and then stopped by braking.

At a speed over 50 km/h, when the vehicle does not reach the required acceleration or speed of the test cycle, the accelerator pedal shall remain fully depressed until the reference curve has been reached again.

To respect human needs, up to three interruptions are permitted between test sequences, of no more than 15 minutes in total.

At the end, the measure D of the covered distance in km is the range of the electric vehicle. It shall be expressed to the nearest whole number."